

THEME SESSION

on

Ecosystem Change in the Baltic (U)

ICES CM 2001/U:00

CORE/STORE–Project: A case study with cooperation between countries inside and outside EU

Brian R. MacKenzie and Friedrich W. Köster

This presentation will describe the scientific background for development and execution of two EU FAIR projects in the Baltic Sea. The projects (CORE: 1994–1998 and STORE: 1999–2002) are investigating fishery and environmental effects on cod and sprat, and predator-prey interactions among cod, sprat and herring. The objectives, principal activities, and partners of the projects will be presented and some of the main scientific results will be highlighted. Emphasis in the projects has been given to processes affecting recruitment and reproductive success in cod and sprat. Evaluation of these processes has required a multi-disciplinary and ecosystem perspective. Examples of scientific findings related to these topics and how the projects are contributing to stock assessment and fisheries management in the Baltic will be presented. In addition, the contributions of EU and non-EU countries to the success of the projects will be described, and the projects' impact on development of new major projects in the region will be demonstrated. This presentation was originally given by invitation at the 11th Meeting of EU Fisheries Directors, Lysekil, Sweden, May 29–31, 2001. Additional information about the projects (work program, EU reports, publications) is available at www.ifm.uni-kiel.de/fi/STORE/welcome.htm and will be presented in other theme session talks.

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ICES CM 2001/U:01

Fecundity of Baltic cod – differences between ICES sub-divisions and variation from 1993 to 1999

M.C. Bleil and R. Oeberst

About 1500 gonads of Baltic cod were analysed for estimating the absolute and relative individual fecundity. The female cods were mainly sampled in the Belt Sea, ICES Sub-division (SD) 22, and in the Arkona Sea, SD 24. Additional samples were also taken in adjacent areas, in the Kattegat, SD 21, and in the Bornholm Sea, SD 25. The investigations started in 1992 and until 1999 different cruises were carried out to catch female cods in the different sub-divisions every year.

The age of the female cods varied from 1 to 11 years. The minimum total length was 21 cm. The largest cod had a total length of 116 cm. The gonads were prepared and preserved in formalin – seawater – solution (4 %) and the number of eggs in a gonad was estimated using the method as described by Bleil and Oeberst (1993). Besides the total length, the total body weight and further parameters were used for describing the variability of the absolute and relative individual fecundity.

A further focus of the analyses is the comparison of the individual fecundity in the different sub-divisions of the Baltic Sea. These results can be important for the stock assessment and also for the separation of both the Baltic cod stocks.

Since, from 1992 to 1999 very different year class strengths of cod were observed in the Baltic Sea, it was also analysed whether significant variations of the individual fecundity existed from year to year or the individual fecundity was comparable in all years.

The analyses showed that the gonadosomatic index is a useful parameter for assessing the physiological status of the maturity development within the maturity stage IV. Furthermore, it could be shown that the developments of the individual fecundity of the western and eastern Baltic cod stocks were different. In contrast to the stable individual fecundity of the western cods the absolute and relative fecundity of the eastern repeat spawners increased significantly from 1993 to 1999. The reason for this development seems to be the dramatic decrease of the eastern cod stock and the

more successful reproduction of cods that produce oocytes with a lower dry weight in combination with a higher relative fecundity.

Keywords: Baltic Sea, cod, fecundity, condition, reproduction.

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Recent changes in diet composition and daily food intake of the Baltic herring in the Gdansk Basin of the Baltic Sea

V.N. Feldman, F.A. Patokina, and N.A. Kalinina

Diet composition, diurnal feeding rhythms, and individual daily food intake of the Baltic herring in the Gdansk Basin are studied on the basis of 4 daily (28-h fishing) stations conducted in July–August 1998 and May 1999. A diet composition analysis of herring stomachs revealed a substantial share of 1-group sprat of the highly abundant 1997 year class in the diet of larger herring. Occasionally clupeid larvae and 0-group sprat of the very poor 1998 year class was observed in herring diet. The significance of the high magnitude of herring predation on sprat described before (Patokina, Feldman, 1998) is confirmed. Feeding conditions and trophic interaction between the two species were compared with those for similar periods during the first half of the 1970s. It is shown that herring predation on juvenile sprat in the end of the 1990s is considered to be of medium importance.

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Changes in distribution, abundance, and population structure of Baltic sprat in 1992–2000

V.N. Feldman and T.G. Vasilieva

On the basis of disaggregated data from hydroacoustic surveys conducted by AtlantNIRO in May–June and October 1992–2000 the distribution patterns of young-of-the-years/recruits and adult sprat in ICES Sub-divisions 26 and 28 of the Baltic Sea are shown. The analysis of age-specific abundance data from hydroacoustic surveys revealed intra-annual meso-scale (between statistical rectangles and depth strata) and interannual large-scale (between subdivisions and basins) changes of the horizontal distribution of sprat. The interannual changes in abundance of sprat between Sub divisions 26 and 28 are related to basin-specific hydrography, while intra-annual variability in meso-scale horizontal distribution of abundance (within Sub division 26) is related to seasonal spawning and feeding migration that is influenced by the depth-specific hydrography.

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A paradigm involving transformation of the Baltic Sea ecosystem and fisheries regimes related to eutrophication, and options for mitigation to redress the root causes

C.C. E. Hopkins, J. Thulin, and E. Hoell

The Baltic Sea ecosystem is highly stressed, exhibiting characteristics of pathological ecosystem deterioration. This paper develops a paradigm for ecological quality of the Baltic Sea, and considers possible mitigatory options for ecosystem restoration, involving the progressive stages of eutrophication that are evident since about 1940, viz:

- Increased inputs and concentrations of nutrients, with substantial changes in some nutrient (e.g. N/P/Si) ratios;

- Raised phytoplankton production and severe shifts in species composition of pelagic algae, with increased likelihood of producing ‘harmful’ algal blooms. Filamentous (‘slimy’) algae are also favoured rather than benthic macroalgae;
- Increased organic sedimentation and decomposition of organic material with resulting hypoxia or semi-permanent anoxia and ultimate production of toxic hydrogen sulphide in the deeper basins;
- Deteriorating water quality causing adverse impacts on amenities and recreational use;
- Changes in the structure and function of benthic food chains and communities, with divergent trends above and below the halocline or oxycline;
- Elevated fish catches in the open Baltic Sea, associated with the effects of eutrophication and increased fishing pressure, as well as decreased predation by substantially reduced stocks of seals. Cod, sprat, and herring account for 80–90 % of the landings. The overall trend in the fisheries regime has contributed towards a decreased size-spectrum in the fish community with increased production being proportionately channelled into small pelagic fish rather than larger piscivorous demersals. In the near-shore areas, some fish species of freshwater origin have increased substantially in eutrophied coastal waters of the Baltic Sea. Because of the change in both the freshwater and marine fish communities, the economic value of the catches for human consumption has decreased.

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Interannual variability trends of sprat egg distribution and environmental conditions influencing egg development in the Gdansk Deep of the Baltic Sea in 1992–2000

E.M. Karasiova and A.S. Zezera

Based on ichthyoplankton and hydrographic surveys in the Gdansk Deep of the Baltic Sea during 1992–2000 the distribution of sprat eggs was studied in reference to the environment conditions. It was revealed that the thickness of the near-bottom layer favourable to sprat reproduction has been decreased significantly as compared to the early 1990s. It is assumed that this decrease caused primarily by oxygen depletion near the bottom has become the factor affecting sprat eggs survival by the end of the period considered.

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ICES CM 2001/U:06

Fish stock development and environmental variability in the central Baltic Sea

Friedrich W. Köster, Christian Möllmann, Stefan Neuenfeldt, Morten Vinther, Gerd Krauss, and Rüdiger Voss

Changes in the abundance of dominating commercially important fish species in the Central Baltic cod, herring and sprat are mainly caused by: i) variable recruitment success influenced by the physical/chemical environment, ii) species interactions, i.e. predation by cod on herring and sprat as well as clupeid predation on cod early life-stages, and iii) fishing pressure on late juveniles and adults. The abiotic environment in the Central Baltic deep basins, being the main spawning grounds of cod and sprat, has changed considerably during the last 25 years. Lacking inflows of North Sea water since the beginning of the 1980s influenced the salinity and oxygen regime and additionally the temperature conditions varied due to atmospheric forcing, with an absence of severe winter situations since 1987. These conditions have directly affected: i) the survival probabilities of early life stages, ii) the food environment of larvae and early juveniles, but also of adult clupeids, and iii) the overlap between predator and prey species. Basically all above processes negatively affected the cod population, while the sprat stock benefited from most, despite a developing industrial fishery.

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Modelling the vertical distribution of sprat eggs in the changing conditions of the eastern Baltic

Andrei Makarchouk

Investigations of the vertical distribution of ichthyoplankton in the Gdansk Deep and the Gotland Basin performed with BIOMOC multiple opening/closing net in 1996–2000 provided the material for this paper. Pelagic eggs of Baltic sprat (*Sprattus sprattus balticus* Schneider) float in a wide range of depths. The mean depth generally decreased during the spawning season. The age structure of the spawning stock also determined the size of spawned eggs, which influenced the mean depth of eggs. Hydrographic conditions in the Baltic Sea, and especially in the deep-water basins in the eastern part have deteriorated in recent years, thus influencing the deeper part of the layer containing sprat eggs. A multiple line regression produced a rather simple model for the determination of the mean depth of eggs, taking into account the Julian day, water temperature of water in the upper layer, mean weighted age of spawners, and the depth of the isooxygen 2 ml/l.

Keywords: Baltic Sea, depth, eggs, model, sprat.

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Variability in population biology of calanoid copepods in the central Baltic Sea

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The copepods *Pseudocalanus elongatus*, *Temora longicornis*, and *Acartia* spp. are the dominant species in the central Baltic Sea. The abiotic and biotic environment of these species has considerably changed during the last four decades. The salinity level declined due to lacking pulses of inflowing North Sea waters and increased river runoff. This is coupled to the atmospheric forcing over the Baltic Sea, which also determines thermal conditions. Additionally the population of the main planktivore species sprat (*Sprattus sprattus*) increased considerably during the period considered, suggesting a substantial increase in predation pressure. Changes in population dynamics of calanoid copepods are investigated by using seasonal time-series of stage-specific copepod abundance covering the period 1959–1999. Changes in stage-structure, mortality, and recruitment are related to the abiotic and biotic ambient conditions. The analysis is performed for the Gdansk Deep and the Gotland Basin, two major deep basins of the central Baltic Sea.

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Main upwelling regions in the Baltic Sea

Kai Myrberg, Oleg Andrejev, Eero Aro, Juha Flinkman, and Harri Kuosa

Upwelling is an important process, e.g., in the Baltic in bringing nutrient-rich waters to the surface layers. Consequently, the surface layers are replenished with the nutritional components necessary for biological productivity. The type of nutrient input – slow diffusion vs. periodic upwelling – also affects the ecosystem structure, the latter leading to generally shorter food chains with higher energy transfer to higher trophic levels.

Our present knowledge of the most important upwelling areas in the Baltic is inadequate and only few comprehensive analyses of these main regions have been carried out. Here, three-dimensional, high-resolution modelling is used as a tool to estimate the spatial and temporal structure of upwellings in the Baltic during the 1990s. According to the results of the simulations, a statistical upwelling index is calculated in order to find the most common upwelling areas. Differences between various years are studied during summer periods. The changes in the overall stratification conditions and their effects to upwelling intensity are studied too.

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Four inland brackish seas: comparative analysis of hydrology and ecology

A.N. Pantiulin and V.S. Arkhipkin

Comprehensive knowledge must be not only deep, but also wide through methods of comparison, analogy, and diversity. Comparison of genesis, evolution and recent conditions in the Baltic, White, Black, and Caspian Seas is carried out in the context of ecology. The Baltic and the White Seas are relatively young, as they appeared about 12000 years ago after the last glaciation. The Black and the Caspian Seas are very old, originating about 5 millions years ago as the remains of the ancient Sarmaticum Sea. The evolution of the seas had unequal duration and conditions, included different chains of events, which changed the affinity by origin between the seas. Several sides of the present hydrological and ecological situation in the seas are discussed. Among these are: temperature, salinity and density structures, convective and advective processes as factors of renewal of waters, circulation systems in the seas, oxygen distribution and regime, the problem of hydrogen sulphide, and so on. The main conclusion of the discussion is that in the present time the Black Sea and the Baltic Sea have the most similar conditions, and particular analysis of the seas may be very effective for understanding the common problems of ecology.

Keywords: Baltic Sea, Black Sea, Caspian Sea, White Sea, ecology, hydrology.

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Long-term changes of oceanographic regime in the Gotland Basin of the Baltic Sea: influence on fish species composition and fishery

Maris Plikshs, E. Jula, M. Fetter, D. Uzars, G. Kornilovs, F. Schvetsov, and A. Makarchouk

The hydrological regime in the Gotland Basin is generally dependent on interaction from North Sea inflow and river runoff. Fluctuations of the hydrological regime have a periodic nature and influence changes in reproduction, biology, and dominance of fish species.

In the present paper, based on the Latvian Fisheries Research Institute's oceanographic monitoring during 1960–2000, the different periods of the hydrological regime in the Gotland Basin have been determined. The cod is the main predator in the Baltic Sea. Its reproduction success and stock abundance in the Gotland Basin is linked to the salinity and oxygen content in deep basins i.e., "reproduction volume". The recent decrease of water exchange with the North Sea lead to prevalence of stagnation processes – reduction of oxygen content, salinity and consequent decline of cod abundance in the ecosystem. Due to a freshening of the sea, the shift from principal benthic food items to less saline coastal living species (fishes and invertebrates) was observed for cod.

Decline of cod abundance also resulted in a drop in predation on the pelagic species sprat and herring. Herring and sprat reproduction is less sensitive to salinity regime and their abundances would have to increase. However, only sprat stock increased, but herring stock decreased in the Gotland Basin. The alterations of the hydrological conditions influenced also the zooplankton community and its species composition and consequently the diet of pelagic fishes. Since the mid-1980s the abundance of main herring food, *Pseudocalanus elongatus* has been at a low level. Herring switched to

smaller zooplankton species and the food competition with sprat became tenser. As a result the growth rates of both main pelagic species has decreased.

The recent changes in the ecosystem in the Gotland Basin in connection with hydrological conditions as well as with the influence of fishery are discussed.

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The analysis of infection of Baltic herring (*Clupea harengus membras*) with *Anisakis simplex* larvae using generalized linear models

M. Podolska and J. Horbowy

A. simplex larvae were counted in the body cavity of Baltic herring sampled in the southern Baltic in 1992–1993, 1995–1997, 1999. The generalized linear models (GLMs) were used to model the prevalence and intensity of herring infection as dependent on year, quarter, area, length, body condition factor, sex, and gonadal development. The binomial error distribution was assumed for prevalence and negative binomial for intensity of infection. The GLM model explained 72 % of deviance of prevalence and all the factors and variables were highly significant. A separate GLM explained 26 % of the deviance of infection intensity and significant effects were length, year, quarter, area and sex. The prevalence increased both with length and condition factor. The prevalence decreased eastward and was higher for herring collected from coastal areas than for hosts from offshore waters. The percentage of infected herrings was highest in the 1st and 2nd quarters (spawning season), and little infection was observed in the 3rd quarter. Prevalence and intensity of infection was higher in males than in females, and the male immune system may be responsible for this phenomenon. The prevalence was stable from 1993 onwards, while the intensity increased sharply in 1997 and 1999. The status of infected herrings is discussed in relation to the model results, but no clear conclusion is reached.

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Recent changes in fish assemblages along the Estonian coast

Toomas Saat, R. Eschbaum, and M. Vetemaa

Standardized gill net monitoring (since 1991) has revealed rapid changes in abundance and distribution of marine and freshwater species, age, length, and sex composition of populations of model species, species richness and heterogeneity of fish assemblages in the Väinameri (Moonsund) and the Gulfs of Finland and Riga. Among freshwater species, abundance of predators (pikeperch, pike, large perch) has decreased (mostly due to over fishing), and abundance of cyprinids has increased (due to the low abundance of predators and warm summers). Among marine species, abundance of flounder has increased all over the coast. This increase, as well as the appearance of some year classes of juvenile cod in recent years is obviously related to the increase in water salinity. Among migratory species, whitefish CPUE has increased in some areas.

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Spatial and temporal variability in the stomach content of herring and sprat in the Bornholm Basin

Matthias Schaber, Christian Möllmann, and Friedrich W. Köster

Herring and sprat stomachs and zooplankton samples were collected on 8 sites in the Bornholm Basin in May/June 1999 at different times of the day. Sprat showed a distinct increase in stomach content from early morning to the afternoon, whereas the stomach content of herring remained rather constant. Both herring and sprat showed a clear

dominance of mesozooplankton in food composition with only small contributions of makrozooplankton and ichthyoplankton. Both clupeid species showed similar preferences in selection of food items with a dominance of the copepods *P. elongatus* and *T. longicornis*. Compared to herring, other copepod species, especially *Acartia* spp. contributed to a larger extent to the food of sprat. Cladocerans played a less important role as food for both species. Spatial differences in stomach content have been revealed between the sampling sites. These resulted from differences in the distribution of food organisms in the water column as well as a different vertical distribution of the predators at different times of day. The share of juvenile copepods in herring stomachs was bigger than in sprat stomachs. Generally, selective feeding seemed to be stronger developed in sprat than in herring.

Keywords: Baltic, Bornholm Basin, feeding, herring, prey-selection, sprat, stomach content.

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ICES CM 2001/U:15

Environmental and fisheries influences on fish stock recruitment in the Baltic Sea (STORE). Summary of results 1999–2000

Dietrich Schnack and Friedrich W. Köster

The effects of abiotic and biotic processes on recruitment of cod and sprat in the central Baltic is presently studied in an EU-funded interdisciplinary research project STORE designed as a follow-up initiative to the Baltic CORE project, carried out in a joint effort of 13 institutes from 8 countries bordering the Baltic Sea. The objectives of STORE are to: 1) Determine stock-recruitment relationships for Baltic cod and sprat in relation to key environmental factors influencing the production of viable spawn and the survival of early life history stages; 2) Improve short-term predictions of stock development by integrating recruitment estimates based on the present status of the stock and its biotic and abiotic environment; 3) Develop predictive recruitment models for medium- to long-term forecasts of stock development under different environmental and fishery scenarios; 4) Estimate biological management reference points, critical stock limits, and target spawning stock sizes based on stock-recruitment relationships and stock development simulation models, and considering the precautionary approach for fisheries management. By addressing these objectives, the project provides a contribution to the GLOBEC Regional Programmes: “Cod and Climate Change” (ICES-CCC) and “Small Pelagic Fishes and Climate Change” (SPACC). The paper presents a general review of results obtained during the second year of the project, finalizing main field and laboratory activities.

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Eutrophication and littoral age-0 fish abundance in the Gulf of Finland, northern Baltic Sea

Lauri Urho, Jakob Kjellman, and Tea Pelkonen

We studied the influence of trophic status on fish reproduction in a coastal area of the northern Baltic Sea. Fifteen years of continuous summertime beach seine data on age-0 fish from three adjacent bays with different eutrophication levels were correlated with water turbidity and phosphorous content that were mainly decreasing over the years. We also related stage-duration with age-0 abundance and as a result, only perch and pike-perch showed a significant negative relationship with the time larvae are in the pelagic area. The age-0 abundances were significantly related to phosphorous and/or turbidity. Herring showed a negative exponential relationship whereas ruffe, bream, and roach had a positive one. Perch, pike-perch, and smelt abundances showed a bell-shaped relationship to phosphorous concentrations 4–90 $\mu\text{g P dm}^{-3}$. The results confirm that trophic changes in water quality already have influence on the abundance of first summer fish, and these species-specific reactions in a marine environment correspond with the changes observed in adult populations of eutrophic waters in general.

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